OIPE IAP37
OCT 14 2005
PATENT & TRADEMARK OFFICE

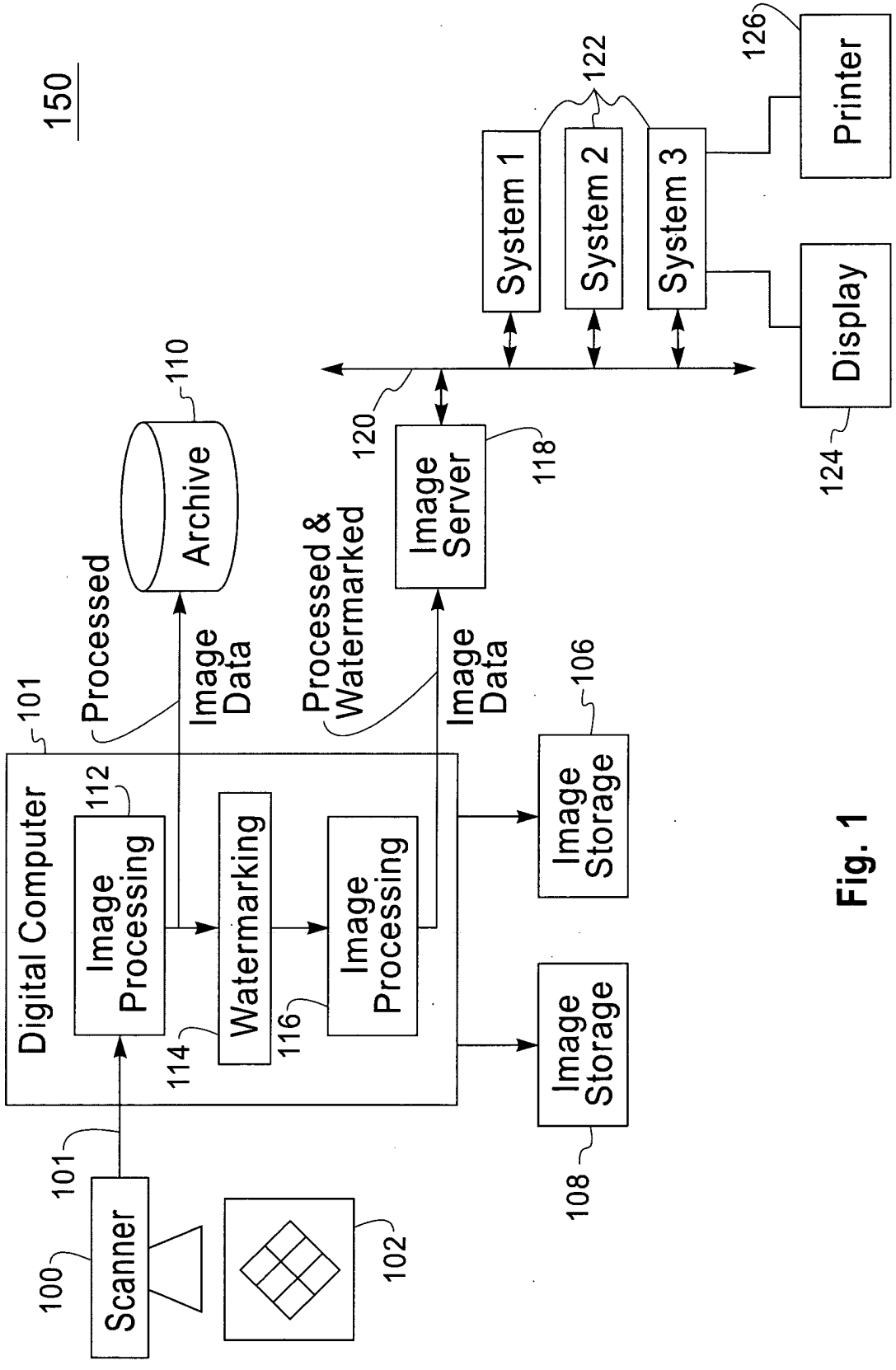

Fig. 1

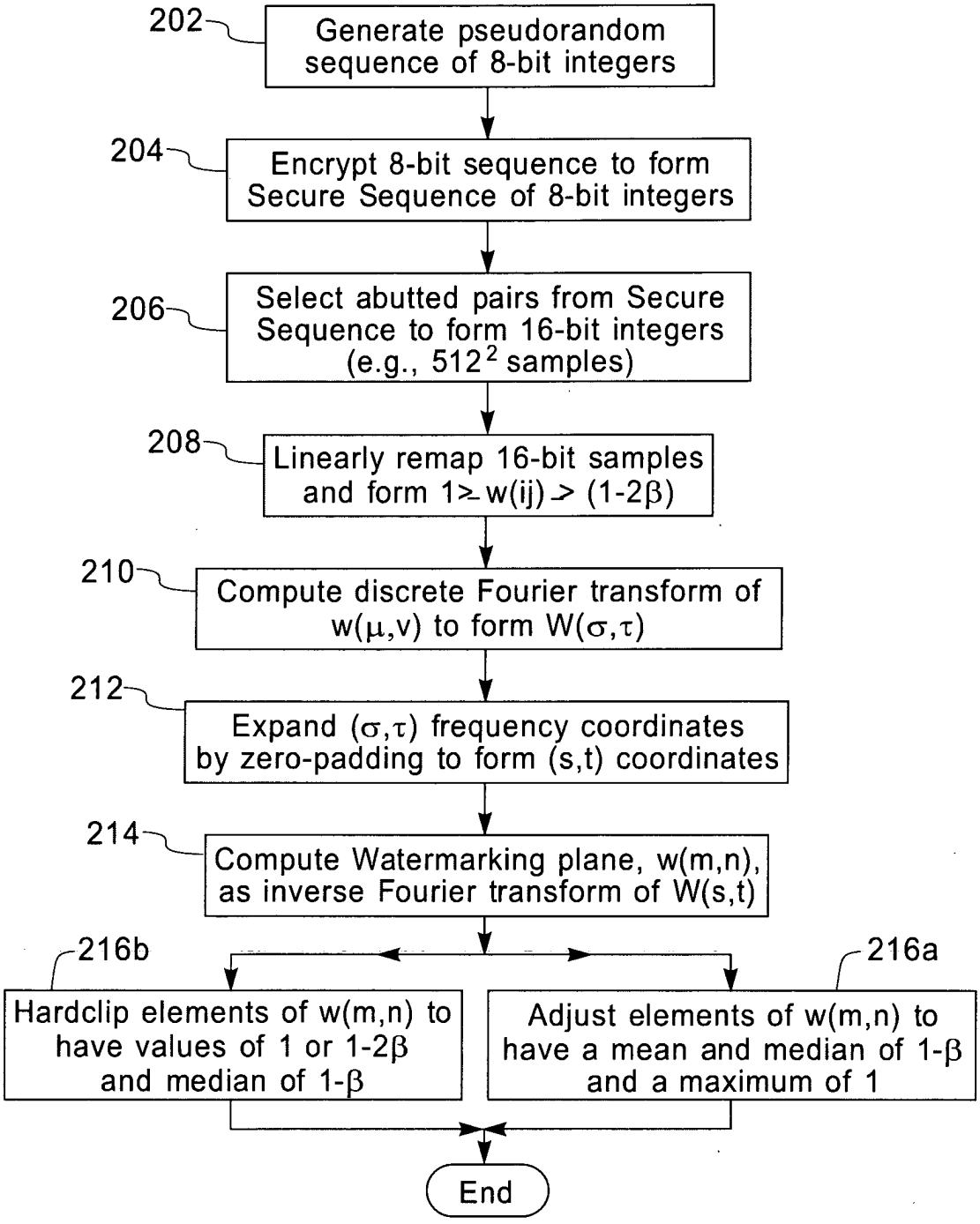
202
Generate pseudorandom sequence of 8-bit integers
204
Encrypt 8-bit sequence to form Secure Sequence of 8-bit integers
206
Select abutted pairs from Secure Sequence to form 16-bit integers (e.g., 512^2 samples)
208
Linearly remap 16-bit samples and form $1 \geq w(ij) > (1-2\beta)$
210
Compute discrete Fourier transform of $w(\mu,v)$ to form $W(\sigma,\tau)$
212
Expand (σ,τ) frequency coordinates by zero-padding to form (s,t) coordinates
214
Compute Watermarking plane, w(m,n), as inverse Fourier transform of W(s,t)
216b
216a
Hardclip elements of w(m,n) to have values of 1 or $1-2\beta$ and median of $1-\beta$
Adjust elements of w(m,n) to have a mean and median of $1-\beta$ and a maximum of 1
End

Fig. 2

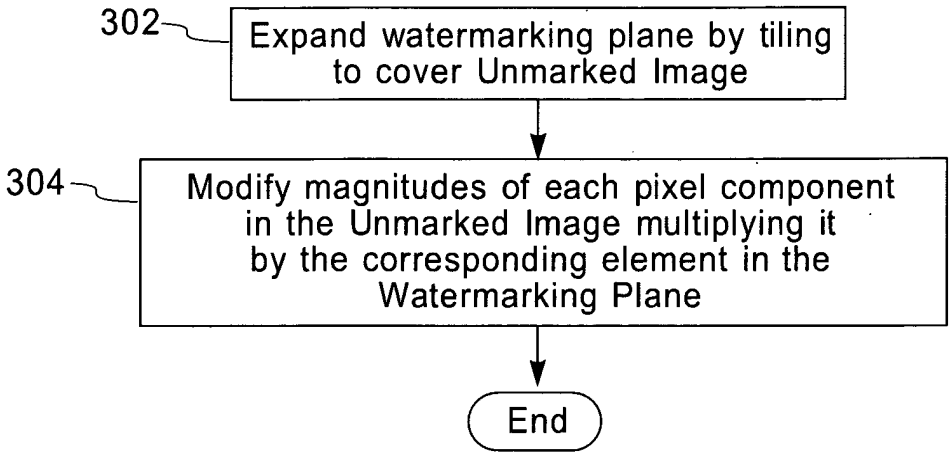
302
Expand watermarking plane by tiling to cover Unmarked Image
304
Modify magnitudes of each pixel component in the Unmarked Image multiplying it by the corresponding element in the Watermarking Plane
End

Fig. 3

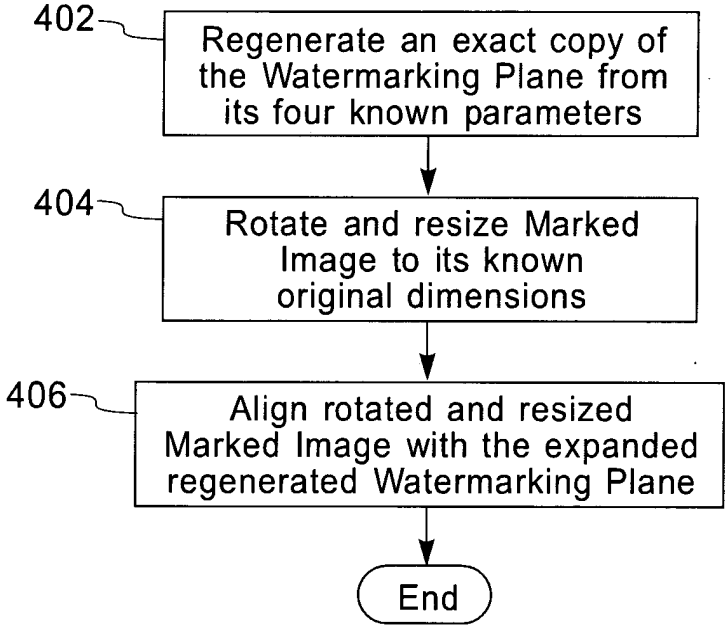
402
Regenerate an exact copy of the Watermarking Plane from its four known parameters
404
Rotate and resize Marked Image to its known original dimensions
406
Align rotated and resized Marked Image with the expanded regenerated Watermarking Plane
End

Fig. 4

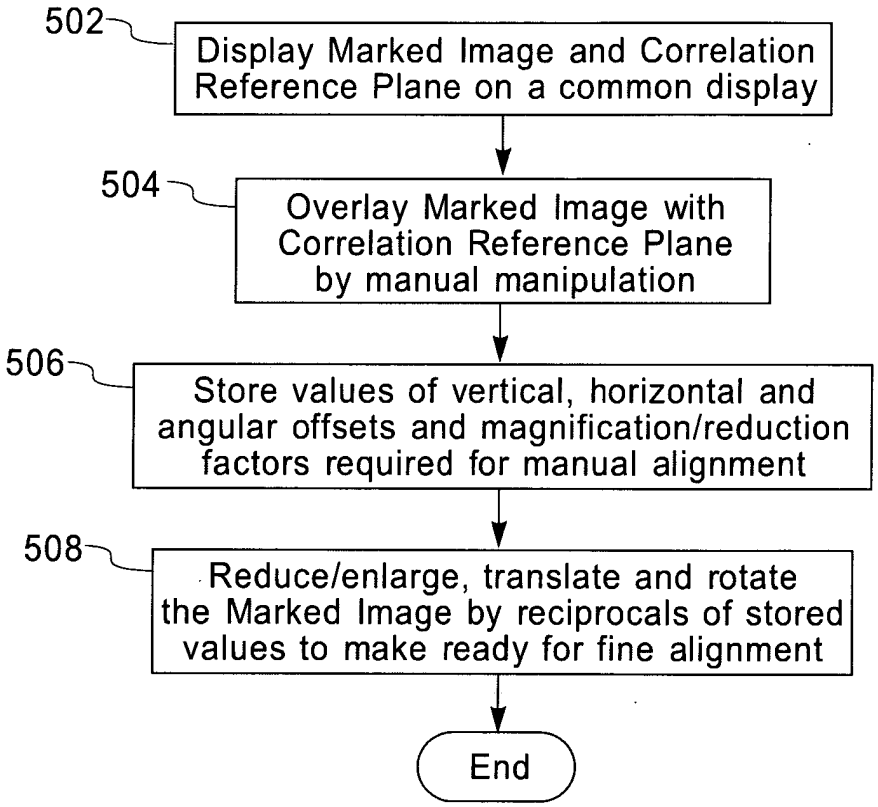
502
Display Marked Image and Correlation Reference Plane on a common display
504
Overlay Marked Image with Correlation Reference Plane by manual manipulation
506
Store values of vertical, horizontal and angular offsets and magnification/reduction factors required for manual alignment
508
Reduce/enlarge, translate and rotate the Marked Image by reciprocals of stored values to make ready for fine alignment
End

Fig. 5

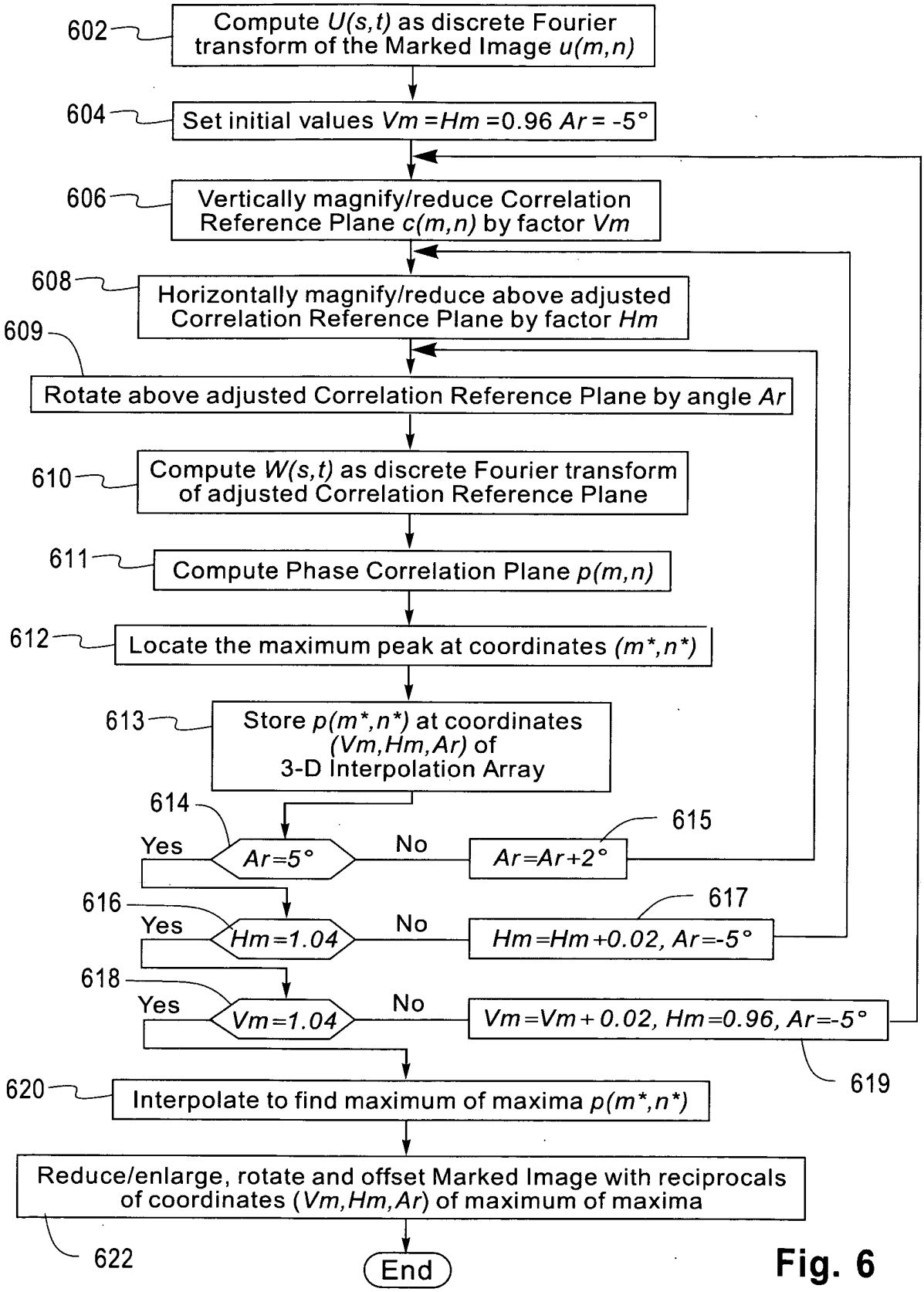
602
Compute U(s,t) as discrete Fourier transform of the Marked Image u(m,n)
604
Set initial values Vm =Hm =0.96 Ar = -5°
606
Vertically magnify/reduce Correlation Reference Plane c(m,n) by factor Vm
608
Horizontally magnify/reduce above adjusted Correlation Reference Plane by factor Hm
609
Rotate above adjusted Correlation Reference Plane by angle Ar
610
Compute W(s,t) as discrete Fourier transform of adjusted Correlation Reference Plane
611
Compute Phase Correlation Plane p(m,n)
612
Locate the maximum peak at coordinates (m*,n*)
613
Store p(m*,n*) at coordinates (Vm,Hm,Ar) of 3-D Interpolation Array
614
Ar=5°
Yes
No
615
Ar=Ar+2°
616
Hm=1.04
Yes
No
617
Hm=Hm+0.02, Ar=-5°
618
Vm=1.04
Yes
No
Vm=Vm+0.02, Hm=0.96, Ar=-5°
619
620
Interpolate to find maximum of maxima p(m*,n*)
Reduce/enlarge, rotate and offset Marked Image with reciprocals of coordinates (Vm,Hm,Ar) of maximum of maxima
622
End

Fig. 6

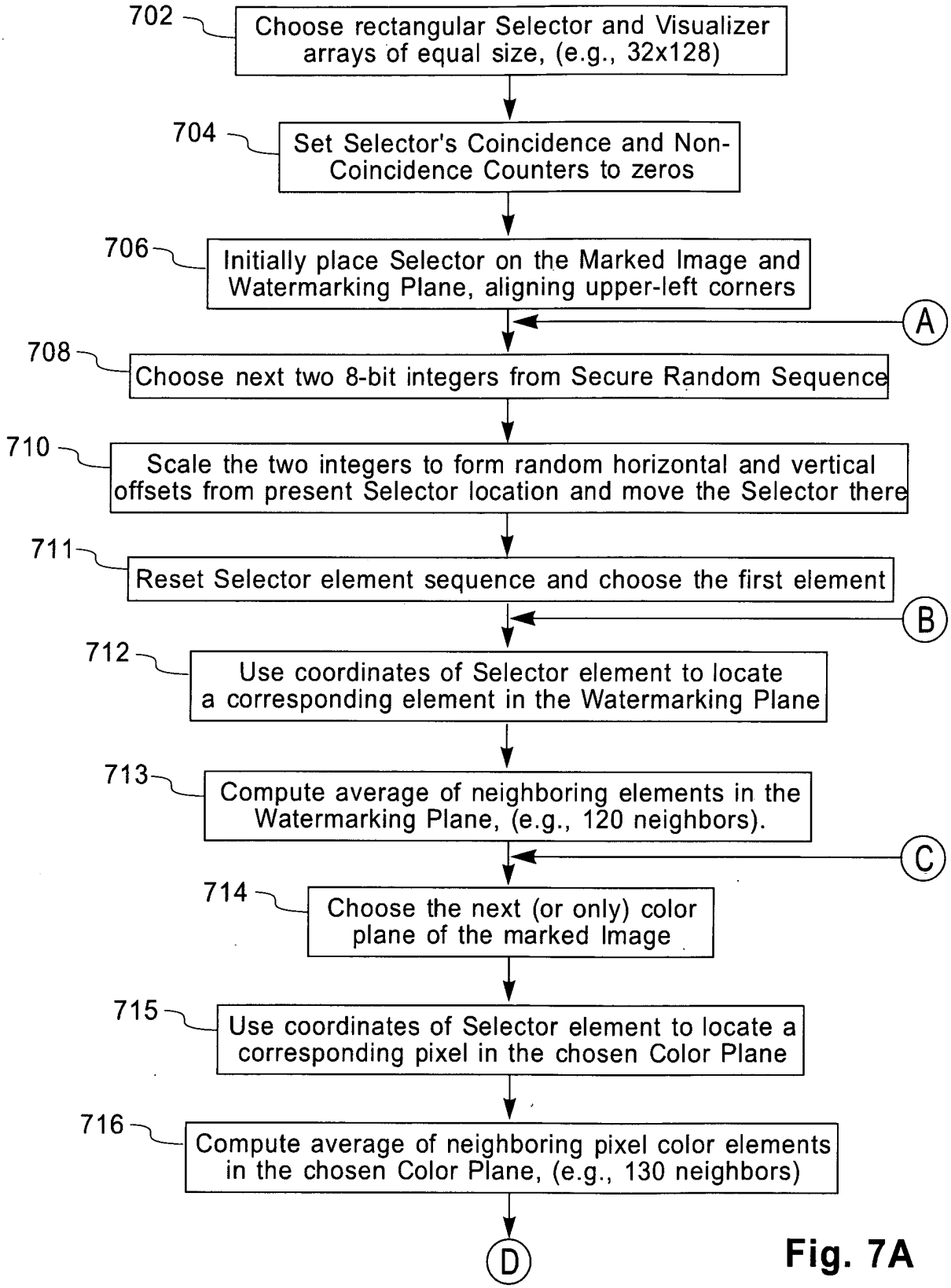
702
Choose rectangular Selector and Visualizer arrays of equal size, (e.g., 32x128)
704
Set Selector's Coincidence and Non-Coincidence Counters to zeros
706
Initially place Selector on the Marked Image and Watermarking Plane, aligning upper-left corners
A
708
Choose next two 8-bit integers from Secure Random Sequence
710
Scale the two integers to form random horizontal and vertical offsets from present Selector location and move the Selector there
711
Reset Selector element sequence and choose the first element
B
712
Use coordinates of Selector element to locate a corresponding element in the Watermarking Plane
713
Compute average of neighboring elements in the Watermarking Plane, (e.g., 120 neighbors).
C
714
Choose the next (or only) color plane of the marked Image
715
Use coordinates of Selector element to locate a corresponding pixel in the chosen Color Plane
716
Compute average of neighboring pixel color elements in the chosen Color Plane, (e.g., 130 neighbors)
D

Fig. 7A

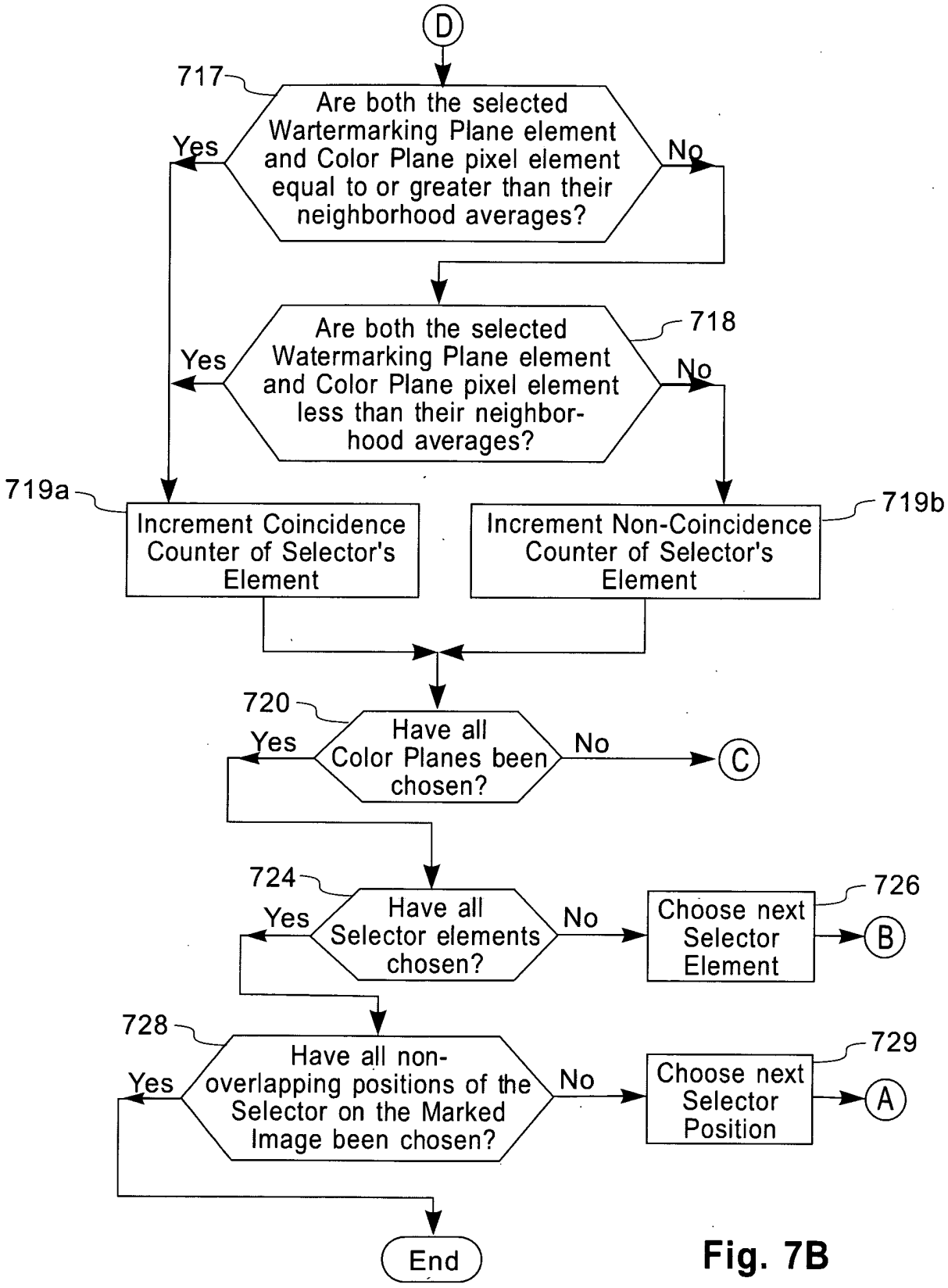
D
717
Are both the selected Wartermarking Plane element and Color Plane pixel element equal to or greater than their neighborhood averages?
Yes
No
718
Are both the selected Watermarking Plane element and Color Plane pixel element less than their neighbor-hood averages?
Yes
No
719a
Increment Coincidence Counter of Selector's Element
719b
Increment Non-Coincidence Counter of Selector's Element
720
Have all Color Planes been chosen?
Yes
No
C
724
Have all Selector elements chosen?
Yes
No
726
Choose next Selector Element
B
728
Have all non-overlapping positions of the Selector on the Marked Image been chosen?
Yes
No
729
Choose next Selector Position
A
End

Fig. 7B

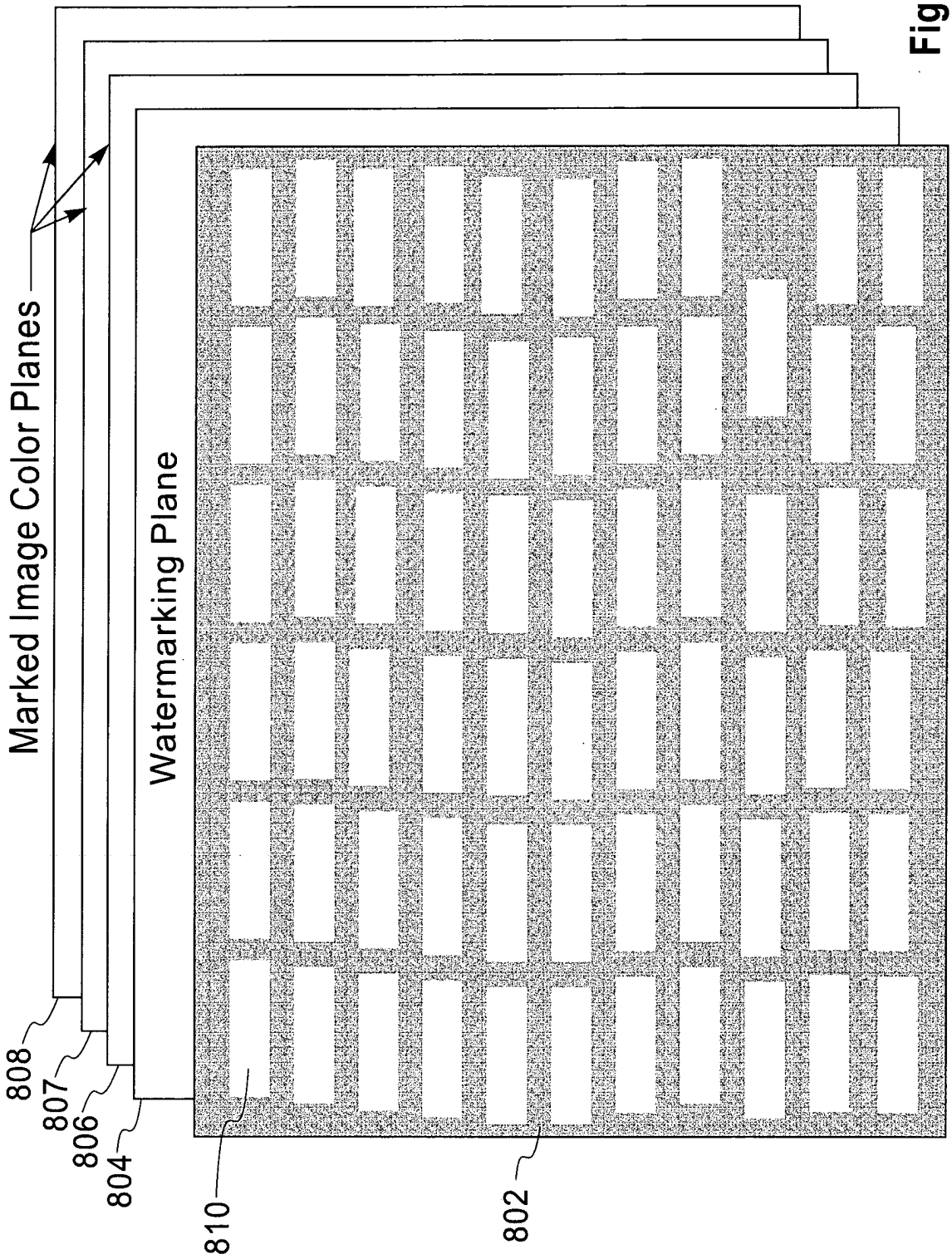
Marked Image Color Planes
Watermarking Plane
808
807
806
804
810
802

Fig. 8

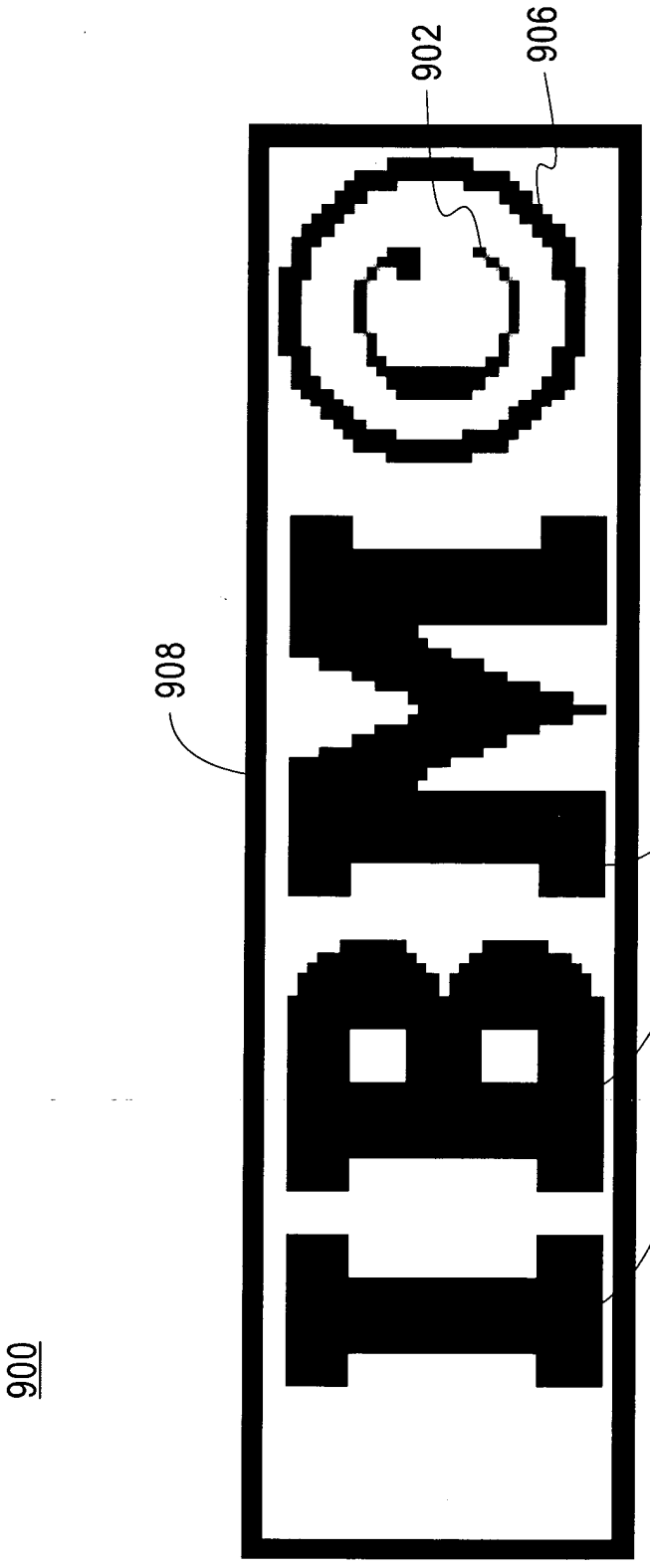

Fig. 9

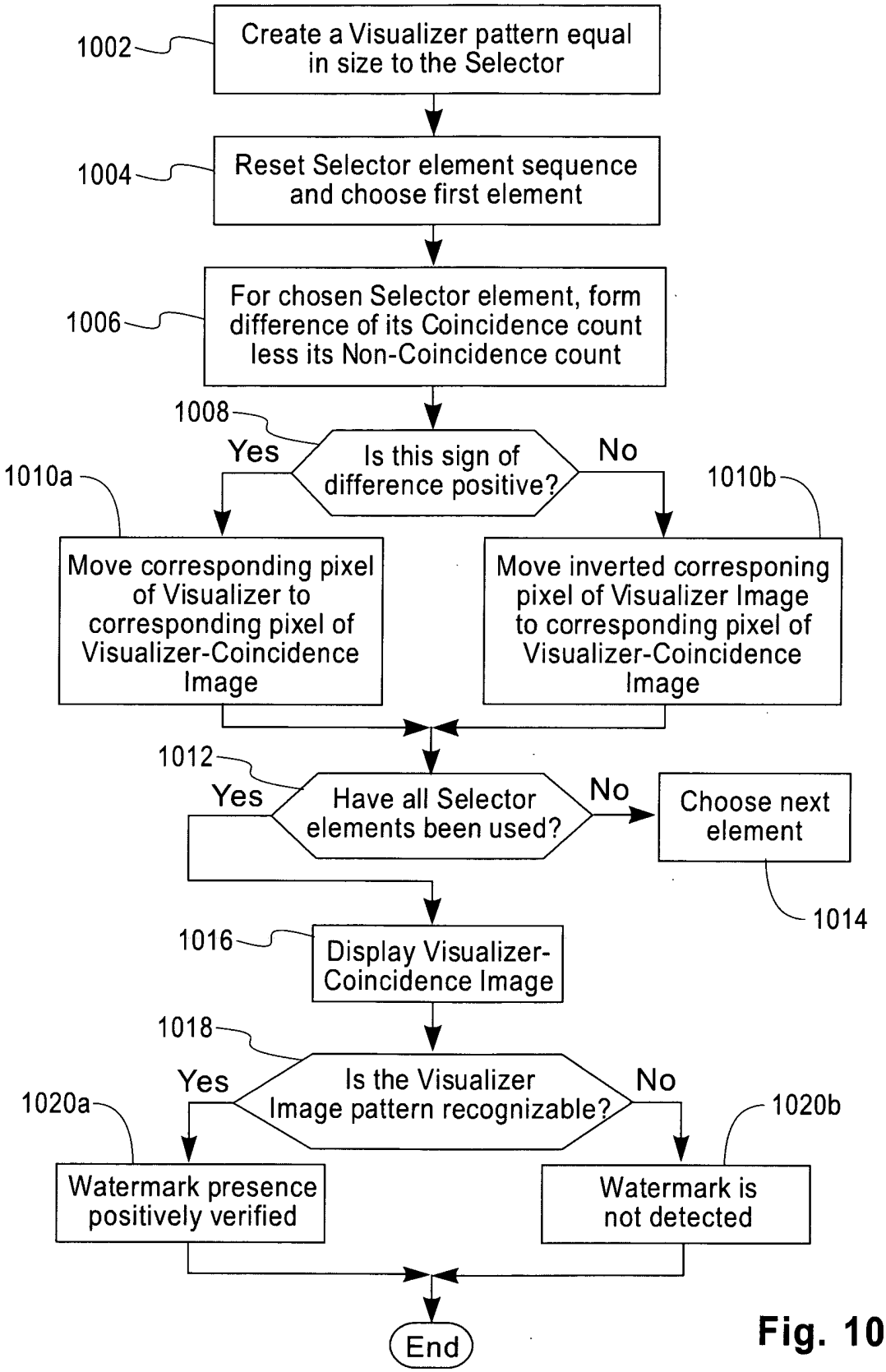
1002
Create a Visualizer pattern equal in size to the Selector
1004
Reset Selector element sequence and choose first element
1006
For chosen Selector element, form difference of its Coincidence count less its Non-Coincidence count
1008
Yes
Is this sign of difference positive?
No
1010a
1010b
Move corresponding pixel of Visualizer to corresponding pixel of Visualizer-Coincidence Image
Move inverted corresponing pixel of Visualizer Image to corresponding pixel of Visualizer-Coincidence Image
1012
Yes
Have all Selector elements been used?
No
Choose next element
1014
1016
Display Visualizer-Coincidence Image
1018
Yes
Is the Visualizer Image pattern recognizable?
No
1020a
1020b
Watermark presence positively verified
Watermark is not detected
End

Fig. 10

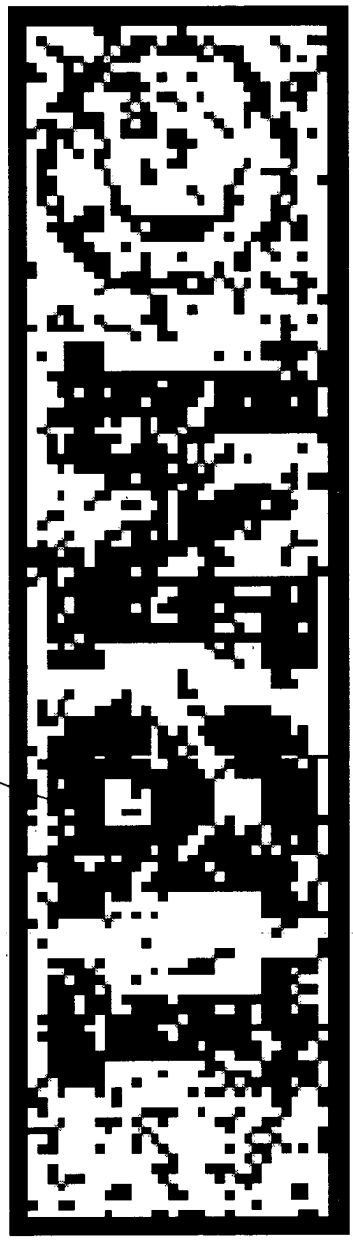

Fig. 11

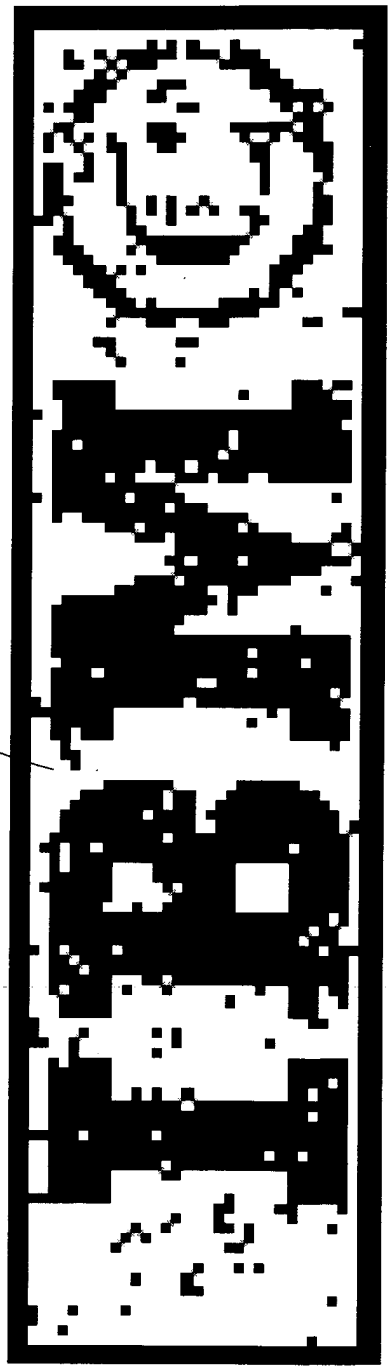

Fig. 12

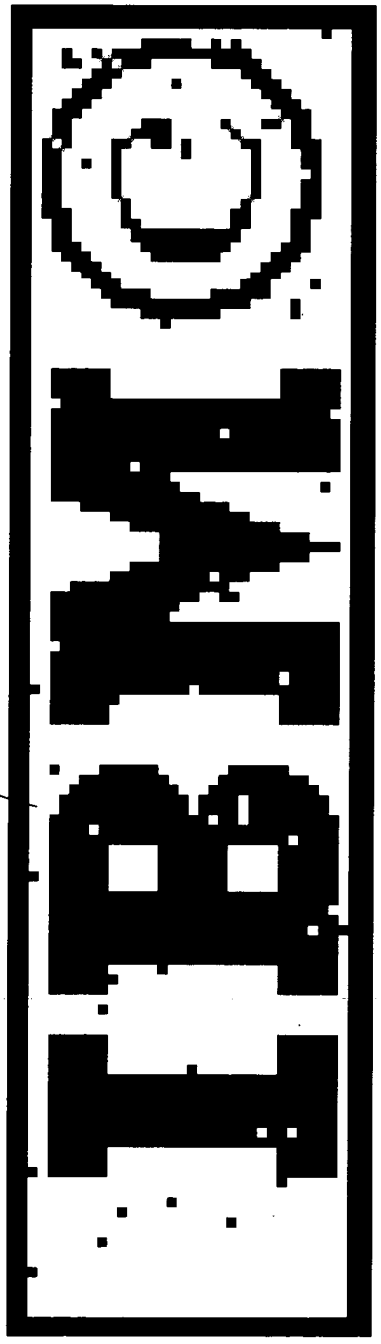

Fig. 13

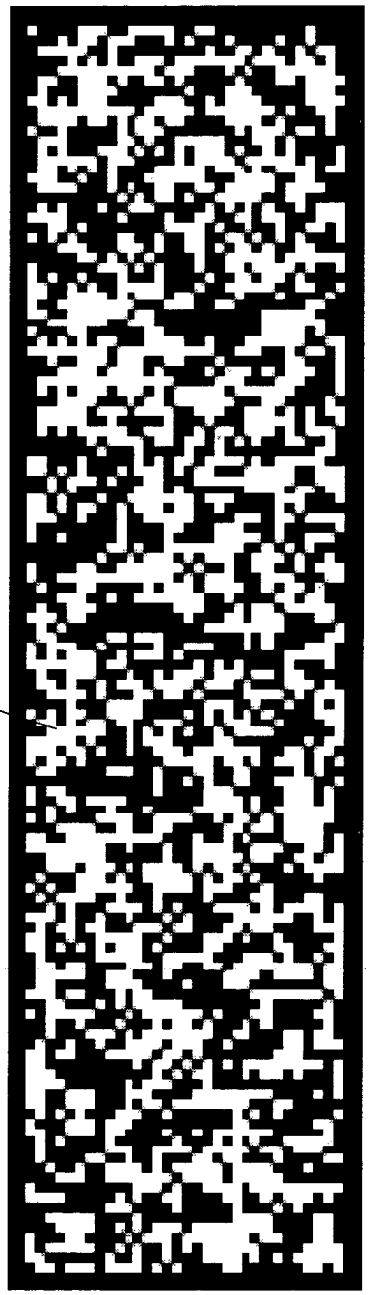

Fig. 14

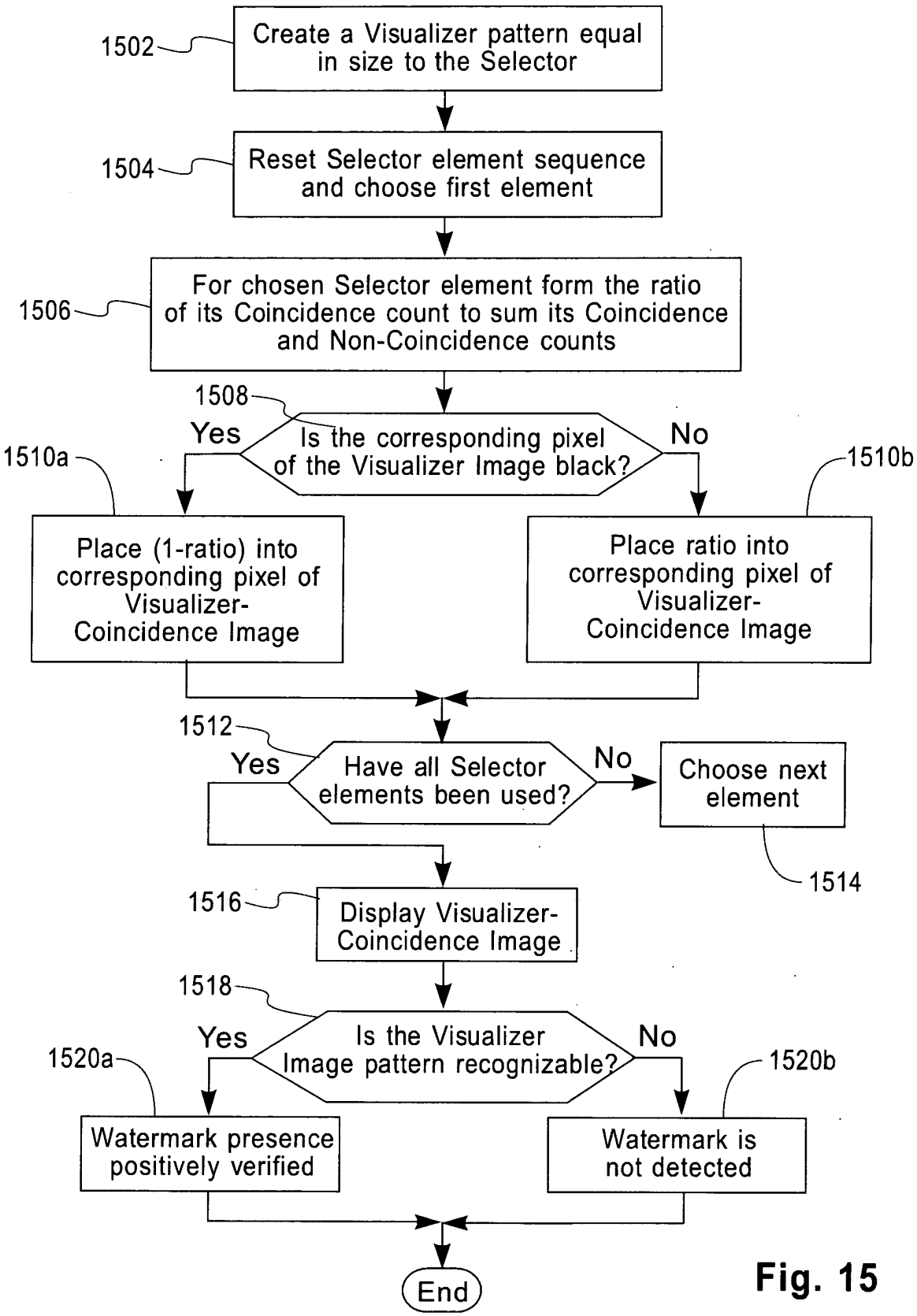
1502
Create a Visualizer pattern equal in size to the Selector
1504
Reset Selector element sequence and choose first element
1506
For chosen Selector element form the ratio of its Coincidence count to sum its Coincidence and Non-Coincidence counts
1508
Is the corresponding pixel of the Visualizer Image black?
Yes
No
1510a
Place (1-ratio) into corresponding pixel of Visualizer-Coincidence Image
1510b
Place ratio into corresponding pixel of Visualizer-Coincidence Image
1512
Have all Selector elements been used?
Yes
No
Choose next element
1514
1516
Display Visualizer-Coincidence Image
1518
Is the Visualizer Image pattern recognizable?
Yes
No
1520a
Watermark presence positively verified
1520b
Watermark is not detected
End

Fig. 15

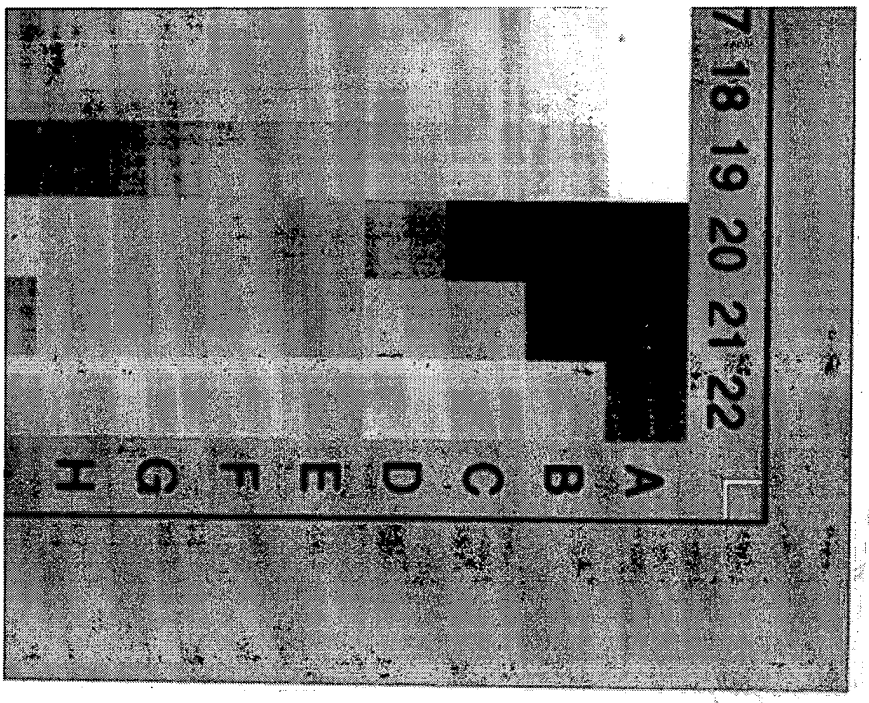

Fig. 16

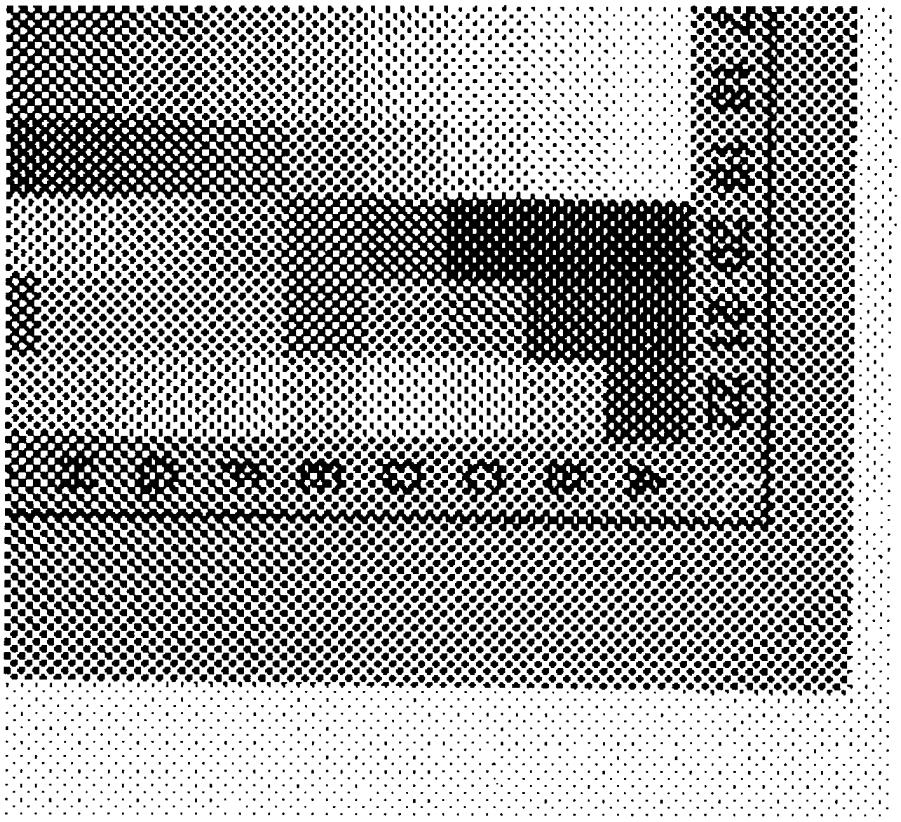

Fig. 17

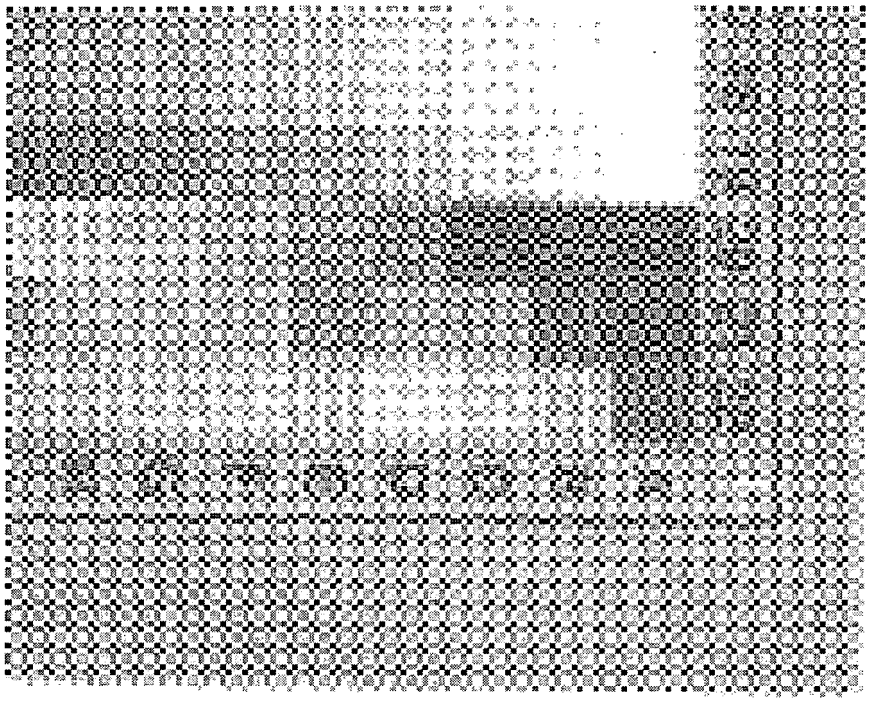

Fig. 18

Fig. 19

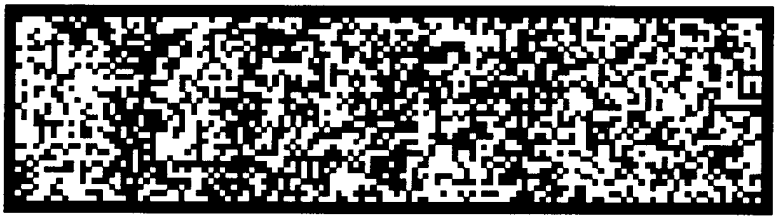

Fig. 20

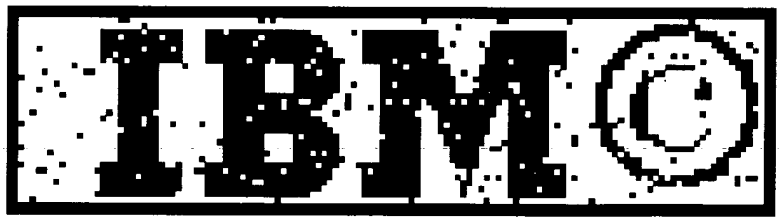

Fig. 21